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ABSTRACT

For over a decade the Public School Forum of North Carolina has used a study group approach that employs the Forum's Board of Directors as a research team that works with others invited to participate in examining major problems facing North Carolina's schools. A request from the Glaxo Foundation led to the Forum's sixth major Study Group. This report contains the results of an investigation into mathematics and science instruction in North Carolina public schools. Findings indicate that while students in North Carolina are much improved in the areas of mathematics and science, they are still lagging in comparison to young people around the world. The study is offered to concerned policymakers, educators and business leaders in the hopes that key recommendations will make a major contribution to education in North Carolina. (Author/ASK)

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ED 421 364

A State of Disconnectedness

An Examination of Mathematics & Science Instruction in the North Carolina Public Schools

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Study Group IV VI

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A State of Disconnectedness

An Examination of Mathematics & Science Instruction in the North Carolina Public Schools – September 1995

Executive Summary . . . 4
Half Way Home... and a Long Way To Go . . . 6
First in Mathematics and Science - Rhetoric or Reality? . . . 8
For Lack of a Center . . . 10
A Wealth of External Resources Contribute to Disconnectedness . . . 11
Diffused Centers of Accountability & No Accountability . . . 12
The Public Policy Pipeline . . . 13
The Teacher Preparation Puzzle . . . 14
Training Opportunities and Lost Opportunities . . . 15
It's a Matter of Time . . . 18
Communication or the Lack of It . . . 20
Equity Issues and Rethinking the Basic Education Program . . . 21
Harnessing External Resources . . . 22
Local Decision Making & State Goals: Avoiding a Collision . . . 23
Bringing It All Together . . . 24
A Starting Point, Not a Final Solution . . . 28
Postscript . . . 29

Foreword

For over a decade, the Public School Forum has used a Study Group approach that has served North Carolina well. The approach employs the Forum's Board of Directors as a research team that, working with others invited to participate in the undertaking, examines a major problem facing North Carolina's schools.

The typical Forum Study Group lasts roughly one school year. It concludes by analyzing a problem and framing recommendations to policymakers, educators, business and community leaders, and others who share a concern about the quality of public education in North Carolina.

Previous Forum Study Groups have proposed the framework for North Carolina's Teaching Fellows Program, the School Accountability & Improvement Act of 1989 (i.e., SB 2), the State's funding formula providing additional funding for low wealth and small schools, and the establishment of a school technology fund.

Having seen the impact of Forum studies, the Glaxo Foundation, created by the Glaxo pharmaceutical firm (now Glaxo Wellcome), requested that the Forum focus its attention on the state of mathematics and science instruction. That request led to the Forum's sixth major Study Group.

The results of that examination are included in this report. As with previous Forum Study Groups, the sixty-person Forum Board of Directors and the twenty-four additional people invited to participate in the examination hope that the results of this effort will not simply end up on library shelves; the study is offered to concerned policymakers, educators and business leaders in the hopes that the recommendations will make a major contribution to North Carolina as it works to create a system of schools which is second to none.

Executive Summary

The academic performance of North Carolina's young people in the areas of mathematics and science holds two very important messages for policymakers, educators, parents and others concerned about the future of the State and its people.

The first message is a message of hope. In recent years, North Carolina students have made steady, albeit slow, academic progress when compared to their peers across the nation. That is a tribute to the State's young people, their teachers and all those who have worked to establish more rigorous academic standards for North Carolina's schools.

The second message holds within it a challenge. While North Carolina's students are making gains, test data comparing our young people with young people around the world find them lagging far behind in mathematics and science skills. If North Carolina hopes to be economically competitive in the years ahead, our challenge is to reach standards of excellence in mathematics and science far beyond those reached today.

Believing that an increasingly technical world will require adults to have a solid foundation in mathematics and science, the Study Group set out to examine mathematics and science instruction in North Carolina. The examination began with an attempt to identify the "center" of coordination for policy making, teacher preparation, and alignment of government and private resources in the areas of mathematics and science instruction in North Carolina.

While the Study Group found a wealth of government and private resources, all working to support stronger instruction in the area of mathematics and science, it found few points of connection; instead, what exists today can best be described as a "state of disconnectedness."

The Study Group concluded that for the State to make real progress, there must be more collaboration, communication and coordination between and among the myriad of government and private entities involved in policy making, training and resource delivery in the K-12 mathematics and science arenas.

The Study Group also found time, or the lack of it, to be a formidable barrier. Today's school calendar severely hobbles teachers by denying them time for training and planning, and it denies young people the time needed to learn how to apply mathematics and science concepts to challenging, real life problems.

Finally, while the Study Group found the State Board of Education's goal of being first in mathematics and science commendable, it found little evidence that the Board's lofty goal had translated into mathematics and science instruction being elevated to an operational priority. Instead, the State Board has imposed more rigorous accountability standards on local school systems while doing little to ensure that government resources are better marshalled to provide school systems the support they will need if they are to reach their goals.

Thus, running throughout this document is a call to the State – especially the Governor and the State Education Cabinet which he chairs – to find new and effective ways to bring the current state of mathematics and science "disconnectedness" into alignment with the State's goal of excellence in the fields of mathematics and science. Key recommendations include:

- A call to the Governor to marshall state and federal resources in the pursuit of new standards of excellence.
- A call to the State's Education Cabinet to make excellence in mathematics and science a top priority for the Cabinet.
- A further call to the Cabinet to clarify lines of responsibility and accountability, especially among colleges, networks, academies and consortia charged with teacher preparation and development.
- A call to the State Board of Education to request that federal funds and programs in the areas of mathematics and science be brought into closer alignment with state goals.
- A call to the State Board of Education to open up direct lines of communication and collaboration between teachers, college faculty, organizations, businesses and private foundations directly involved in providing or supporting mathematics and science instruction in North Carolina.
- A further call to the State Board of Education to maximize collaboration between the State Board and the North Carolina School of Science and Mathematics, especially in the area of effective utilization of their innovative advances in long-distance learning for classroom instruction, teacher development and communication.

- A call to the National Science Foundation to align the resources of its Systemic State Initiative with the Education Cabinet in such a way that a major effort could result without the creation of another state bureaucracy or large additional expenditures of tax dollars.
- A call to the Community College System to focus on ways the System and the public schools can accelerate development of instructional approaches based upon application of mathematics and science skills to challenging problems with a movement away from reliance on memorization of large amounts of material.
- A call to the UNC Board of Governors to bring greater cohesion to those teacher preparation and training functions housed within the university system.
- A call to the General Assembly to support the Education Cabinet, if they request legislative changes that would be required to clarify today's muddled lines of accountability, especially in the area of teacher preparation and training.
- A further call to the General Assembly to address the limitations of today's school calendar both in terms of time for learning and time for teacher training and planning.

Half Way Home... and a Long Way To Go

Describing the Southeast Region's attempts to economically "catch up" to the rest of the nation, the Southern Regional Growth Board issued a report in 1988 called *Half Way Home and a Long Way to Go*. The same description could be applied to the United States and North Carolina as both attempt to raise levels of student performance to the point that our young people are competitive in mathematics and science with young people across the world.

International comparisons of how well students in different countries perform in mathematics and science find U.S. students near the bottom in test after test (see chart below).

Science		Mathematics	
Country	**Proficient %**	**Country**	**Proficient %**
Korea	78%	Korea	73%
Taiwan	76%	Taiwan	73%
Switzerland	74%	Switzerland	71%
Hungary	73%	Soviet Union	70%
Soviet Union	71%	Hungary	68%
Slovenia	70%	France	64%
Italy	70%	Italy	64%
Israel	70%	Israel	63%
Canada	69%	Canada	62%
France	69%	Scotland	61%
Scotland	68%	Ireland	61%
Spain	68%	Slovenia	57%
U.S.	**67%**	Spain	55%
Ireland	63%	**U.S.**	**55%**
Jordan	57%	Jordan	40%

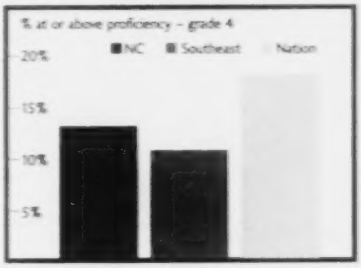
Source: IAEP 1990-91 assessment of student proficiency, ages 9-13.

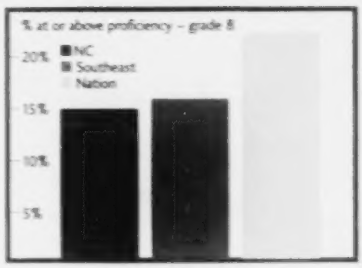
Study after study also document America falling behind in industries requiring high levels of skills. Again, the low-level of mathematics and science ability in the typical high school graduate is cited as a major contributor to the nation's slippage in high skill, high wage industries especially in contrast to nations like Japan and Germany where high school graduates have mathematics and scientific skills rivaling those of college graduates in the United States.

The cumulative findings of these studies have created a focus on school reform in the public schools unequaled since the launching of Sputnik sparked a similar response in the fifties and sixties.

For North Carolinians, state test scores tell two stories. On one hand, the State has and is responding to the urgent need to improve student performance in mathematics and science. In recent years, North Carolina has shown slow, but steady, improvement in the two most-often cited national tests – the College Board Entrance Exam (SAT) and the mathematics portion of the National Assessment of Educational Progress (NAEP) test.

Levels of Mathematics Achievement





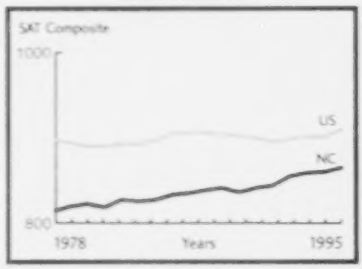
Source: NAEP 1992

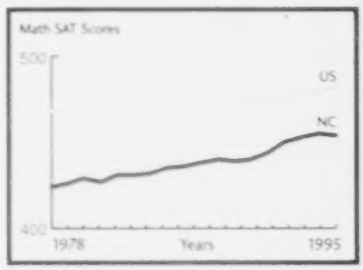
When the State re-administered the NAEP test in 1994, North Carolina's fourth graders scored above the 1992 national averages. In recent years, North Carolina's high school students have made the nation's largest gain on SAT tests.

That is the good news; however, such news merely underscores the distance North Carolina has to go before it becomes a national leader in mathematics and science within the United States, not to mention the world.

The recently released 1995 SAT scores stand as mute testimony to the problem. After a decade of school reform, the State remains 48th in the nation – exactly where it was over a decade ago. North Carolina's top achieving students trail behind the

National & North Carolina SAT Scores





top achievers nationwide; North Carolina's minority students lag far behind their majority counterparts; students in North Carolina's poorest school systems score starkly lower than their peers in wealthier systems.

No matter how one views international and national comparisons in the area of mathematics and science, North Carolina is confronted with a harsh reality:

The United States, compared to economically competitive nations, ranks near the bottom in student performance in mathematics and science. North Carolina, despite steady and commendable progress, trails most states making the State's challenge graver and more urgent.

While statistics comparing students in North Carolina to others are instructive, as important are other messages found in test data:

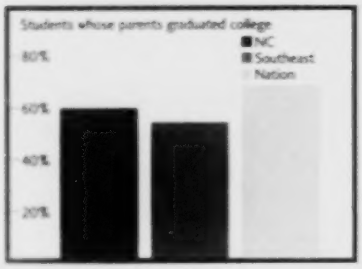
- There is a direct correlation between the educational level of parents and their students' performance on mathematics and science tests. The higher the educational attainment level of parents, the better the performance of their children.
- There is a large mathematics and science performance gap between students in North Carolina's wealthiest and poorest counties. Comparing the ten wealthiest school systems to the ten poorest systems, one finds a 58 point difference on the mathematics section of the SAT.
- There is an even larger gap between African-American and white student performance. Only 3% of North Carolina's African-American students in 1990 and 4% in 1992 were rated proficient in mathematics compared with 16% of whites in 1990 and 20% in 1992.
- In North Carolina, 77% of 8th grade African-Americans scored below the basic level in mathematics in both 1990 and 1992 on the NAEP test.
- Nationally, between grades 4 and 12, the gap in science proficiency between males and females widens from 2 to 10 points. Females in North Carolina fell further behind males from 1990 to 1992 on the NAEP tests.
- Nationally, 8.7% of all college freshmen participated in remedial mathematics courses; in North Carolina, 13.7% of all college freshmen take remedial mathematics courses.

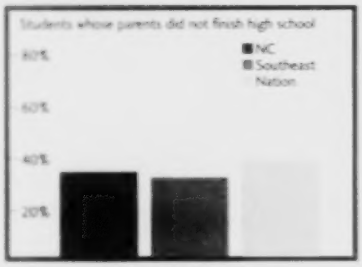
The data paint an unsettling picture. As unsettling are the results of other studies and surveys comparing young people in areas like assigned homework. For instance:

- In Korea, 73% of 13-year-olds were proficient in mathematics and 68% reported 1-3 hours of homework per night. In the U.S. only 55% of 13-year-olds reached proficiency and only 39% reported 1-3 hours of homework per night.
- U.S. students do roughly the same amount of homework in one week as Japanese students do in one night.

While it is difficult to single out "the" major cause for low performance, the messages in the data sound an alarm that should lead to a redoubling of the efforts which are bringing today's steady, but painfully slow, progress.

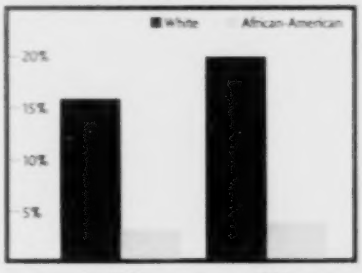
Percentage of 4th-Graders at or above Basic Level in Math

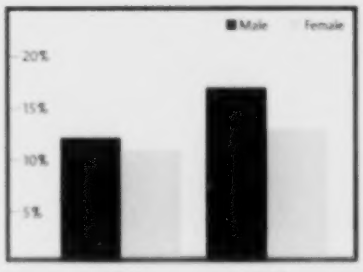




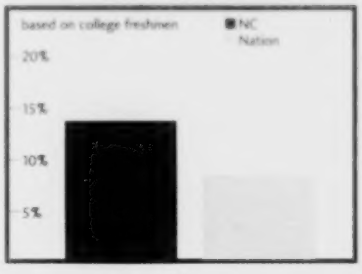
Source: NAEP 1992

Percentage of NC 8th-Graders Proficient in Math





Percentage Enrolled in Remedial Math Courses



First in Mathematics and Science – Rhetoric or Reality?

"United States students will be the first in the world in science and mathematics achievement." (Goal Four of the eight national educational goals adopted by the nation's governors and former President George Bush and later reaffirmed during the Clinton administration.) In October 1993, the North Carolina State Board of Education adopted the national goal of being number one in mathematics and science as its own.

"The Goals 2000 mathematics and science goal is impossible; therefore, it's irrelevant." – Faculty member who coordinates the Mathematics and Science Education Network's program for one of UNC's universities.

"When the Malcolm Baldrige Awards began recognizing companies for excellence, IBM set as a goal winning the Baldrige Award. On reflection, however, we realized that we had set the wrong goal – our goal should have been to be excellent in those things we set out to do. It struck us that if we could organize ourselves in such a way that there would be continuous improvement in our striving for excellence, awards would come if we made progress – and they did. After making the search for excellence our goal, the corporation became a Baldrige Award winner." – Bob Harris, formerly of IBM's Research Triangle facility.

When the nation's governors and president adopted national education goals in 1989, the goal which many privately viewed as wishful thinking was Goal Four which said American young people would be first in the world in mathematics and science by the Year 2000. It is a goal which many, including the college faculty member cited above, dismissed as "impossible" therefore "irrelevant."

Skepticism aside, states across the country, including North Carolina, soon adopted the goal as their own.

It may be that we have adopted a consequence as a goal. Does the Baldrige Award story above point to a different, and possibly better, goal? As the anecdote describes, rather than setting out to be an award winner, IBM set out to be excellent in what it did. Its presumption was that if excellence became its norm, awards would follow – and follow they did.

Comparing North Carolina to business, our goal should be to embrace a vision of what we want young people to know and be able to do – not, as we are at the moment, keying on minuscule gains on an SAT score which only move us closer to 47th place. If our vision for improvement rests on test scores alone, we may continue to make steady but unimportant gains on test scores while our young people lag further behind in an increasingly information-driven, technological world.

It is not enough to set out to improve test scores; rather, the State needs to build a consensus around its own vision and goals for mathematics and science instruction.

It is not enough to set out to improve test scores; rather, the State needs to build a consensus around its own vision and goals for mathematics and science instruction and systematically and relentlessly do what it will take to achieve them.

Thankfully, three years of work on the part of North Carolina's Standards and Accountability Commission have produced a vision of what could be and accompanying goals which the State could embrace.

The Commission went far beyond studying how North Carolina's young people do on standardized tests. They looked at the differences between instructional goals. What, they asked, are high-achieving countries doing differently? What lessons could be learned and applied to mathematics and science in North Carolina?

The Commission's conclusions are powerful. The overwhelming difference between mathematics and science instruction in the United States and in other countries is our focus on "covering" large amounts of material; high achieving countries, on the other hand, focus on how to apply knowledge to real-world problems.

Our system of college entrance requirements, our curriculum expectations, and our testing programs force classroom teachers to "complete textbooks," to make sure students have "covered" material. In contrast, other countries ensure that students build the capacity to apply what they learn to real-life situations. There is time for students, alone and in groups, to use mathematics and science concepts as they solve challenging problems. The focus is on problem solving and mastery of material – not on coverage of material.

Thus, the North Carolina Standards and Accountability Commission is proposing a dramatic overhaul of curriculum goals. It contends that the goal of mathematics and science instruction should be to produce students capable of applying mathematics and science knowledge to the kind of problems they will be expected to solve as adults.

If the State relentlessly pursues the goal of excellence in mathematics and science instruction leading to high school graduates capable of applying mathematics and science concepts to solving the kinds of problems they will confront as adults, becoming a leader in the country, and perhaps the world, should follow.

That goal, if embraced by the State, would lead to a dramatic revision in today's approach to teaching and testing. Instead of administering multiple choice tests at the end of a chapter and "moving on" to the next chapter, it would mean that students would be challenged with problems requiring them to apply and build on what they have learned.

That goal also addresses what large and small employers in North Carolina want from North Carolina's schools. The North Carolina Workforce Preparedness Commission conducted surveys which mirror what employers across the country say employees must have if we are to remain competitive. They want high school graduates who have basic computational skills; but, more importantly, they want graduates who are able to use those skills on the job.

The Commission's thinking is much more attuned to a search for excellence. If North Carolina's goal is to produce students capable of using mathematics and science to address real problems, instruction becomes more than memorizing facts for a test and promptly forgetting them, secure in the knowledge that once the course is ended there will be no need to remember them any longer.

That is a vision for mathematics and science instruction upon which the State could marshal its resources. It establishes a goal of excellence that would set a direction for teacher training, for scheduling time, for adapting technology.

If the State relentlessly pursues the goal of excellence in mathematics and science instruction leading to high school graduates capable of applying mathematics and science concepts to solving the kinds of problems they will confront as adults, becoming a leader in the country, and perhaps the world, should follow.

Ten Essential Skills

1. **Reading**
2. **Writing**
3. **Speaking**
4. **Listening**
5. **Observing**
6. **Using Numbers and Data**
7. **Critical Thinking**
8. **Creative Thinking**
9. **Problem Solving**
10. **Team Work**

Essential Skills NC Graduates Should Possess: Identified by the NC Standards and Accountability Commission

For Lack of a Center

"If all of us involved in mathematics and science could be woven together into a patchwork quilt, we could cover every student in North Carolina; as it is, we are a series of unconnected patches." – Dr. John Friedrick, the Director of the NC School of Science and Mathematics

"The reason we don't move in the same direction is that we can't decide whose drum to march by." – Tony Habit, the Executive Director of the Durham Public Education Network

"The State has a whole lot of programs going on (i.e., in the mathematics and science arena) and we don't know if they are doing well; it is a lot of helter-skelter stuff." – Dr. John Griffin, Superintendent of the Cumberland County Schools

"My colleagues in the business community don't know which mathematics or science programs to support. All of the ideas sound good. Communities need a master plan and key people need to be part of making it; then someone needs to educate business groups that want to help." – Larry Seigler, Director of Community Affairs for one of Greenville, North Carolina's, largest employers

"There is a real lack of information about what is happening in mathematics and science; everything seems to be in a state of transition." – Martha Peck, Executive Director of the Burroughs Wellcome Fund, describing what they found when they undertook an assessment of North Carolina's mathematics and science programs

There is no lack of effort by the State in working to improve mathematics and science performance and instruction. Many organizations and programs are making important contributions to enhance the skills and knowledge of teachers, to create a curriculum that is process-oriented and focused on hands-on problem-solving, to involve business in mathematics and science partnerships at the school building level.

The Study Group found that the State does not suffer from a lack of attention to mathematics and science. What the Forum could not find, however, was evidence of coordination of myriad efforts in the mathematics and science arenas.

Instead, one needs to look in one direction to find out what is happening in teacher training; one must look elsewhere to find out how teachers receive additional training once on the job; to find where the State is going in curriculum and testing one has to look somewhere else.

The search for a center ended with the realization that there are multiple centers of mathematics and science coordination. Everyone and no one is finally accountable for improving mathematics and science instruction in North Carolina's public schools.

By virtually everyone's admission, there is no center for coordination, for setting directions, for aligning resources for mathematics and science instruction in the public schools of North Carolina.

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If there could be one phrase that describes the current state of mathematics and science in North Carolina's K-12 schools, it would be "a state of disconnectedness." Different, overlapping and, in some cases, competing state and federal departments and agencies are all "doing things" in the mathematics and science arena. Rarely, however, do they know what other agencies and departments are doing; even more rarely do they cooperate, plan in advance and share what they are learning.

At the same time, the public school teachers who finally will make, or not make, a difference in raising the performance of North Carolina's young people, are typically the last to know where the State is headed. Worse yet, they are almost always the last to be asked where the State should be headed – much less how to get there.

At best, communication between the State's top educational officials and its teacher practitioners is limited; at worst, it is nonexistent. The same communications problem exists between the State and those charged with preparing and training teachers.

The following chapters will look at examples of where disconnectedness, blurred accountability lines, and unclear goals and communication take a toll on the State's efforts to improve mathematics and science instruction and performance. With that, this report will attempt to lay out a road map for improvement that can be followed by policymakers, educators and business leaders who share a vision of North Carolina education reaching new standards of excellence in mathematics and science.

A Wealth of External Resources Contribute to Disconnectedness

When the Study Group began its work, many assumed that a lack of resources would quickly surface as both a pressing problem and cause of North Carolina's poor student performance in mathematics and science.

While few involved in the study would disagree that schools could use more funds for staff training, technology, lab equipment and updated material, what the Study Group found was not so much a lack of available funding; rather, millions upon millions of additional dollars – dollars above and beyond the State's basic funding for instruction – are spent on mathematics and science activities.

- Two federally funded programs alone pump in millions of dollars each year into programs intended to strengthen mathematics and science initiatives in North Carolina. Federal Eisenhower funds of nearly $6 million are earmarked for teacher training in mathematics and science. The National Science Foundation (NSF) funds approximately $15 million for North Carolina mathematics and science programs ranging from teacher training to technology applications to research.
- Scores of locally supported educational foundations and partnerships annually fund hundreds of local programs ranging from tutoring at-risk students in mathematics and science to outfitting state-of-the-art labs, to special summer training programs for teachers of mathematics and science.
- Large and small corporations from one end of North Carolina to the other are major supporters of innovative programs aimed at improving mathematics and science instruction in the State's public schools.
- State-funded science museums and many state-funded colleges have extensive mathematics/science outreach programs with surrounding K-12 school systems.
- State and federal agencies outside education – ranging from NASA to the Environmental Protection Agency to Forestry to the Department of Agriculture – annually spend millions of additional dollars preparing curriculum material, conducting special projects with K-12 school systems and providing summer training opportunities for K-12 teachers.
- Dozens of nonprofit organizations, ranging from Cities In Schools to 4-H to the Sierra Club, produce curriculum material related to mathematics and science, conduct innovative programs or provide tutoring of low-performing students.
- State and corporate dollars support a growing number of long-distance learning experiments. Some rely on satellite transmission, some on phone wires and a growing number on the State's burgeoning information highway network.
- The North Carolina School of Science and Mathematics has been a model for fifteen other states which have established similar schools. Year-after-year, the school is recognized for ground-breaking work in the field of mathematics and science.

Rather than being a problem of woefully few resources, the problem is more one of woefully little coordination between the myriad number of governmental and private attempting to improve mathematics and science instruction in North Carolina.

Rather than a problem of woefully few resources, the problem is more one of woefully little coordination between the myriad number of governmental and private organizations attempting to improve mathematics and science instruction in North Carolina.

In many cases, and especially in the case of the federal government's National Science Foundation (NSF) awards, the keen competition for grant dollars makes coordination and cooperation even less likely. Nonprofits, K-12 schools, public and private colleges and state agencies alike compete for NSF dollars. Once awards are granted, the only accountability grant recipients have is to the NSF which can extend awards beyond the original grant or end the funds at the end of a grant cycle. The State has little, if any, say over how the largest amounts of federal mathematics and science resources are used.

If all, or even most, of the external resources coming into the State's schools were to have a clear road map of most-productive programs; if they were to have clear understandings about the needs of the State; and, if they were to cooperate in planning and sharing, the programs could have far greater impact than they do today.

Diffused Centers of Accountability & No Accountability

"Today we are structured to fail; our challenge is to structure ourselves for success." – Howard Haworth, former chair of the NC State Board of Education

The chart on the following page shows the labyrinth of organizations, institutions, state and federal departments and agencies that are currently "doing something" in policy making impacting math and science. The next chart shows the myriad groups responsible for, or providing, teacher training in mathematics and science. What both illustrate is an organizational design nightmare, a system almost incapable of working as a whole. Looking first at how public policy for mathematics and science is developed, in the words of the director of the NC School of Science and Mathematics, *"If all of us involved in mathematics and science could be woven together into a patchwork quilt, we could cover every student in North Carolina; as it is, we are a series of unconnected patches."*

The question for policymakers, especially for members of the State Education Cabinet, is how can "a disconnected series of patches" come together to form a patchwork quilt capable of encompassing the entire State and its 1.2 million young people in public schools? A large part of the answer may be found by determining the locus of accountability for mathematics and science performance and by reordering years of short-term, expedient policy-making that has resulted in a muddled and overlapping maze of jurisdiction and accountability.

The General Assembly, through its budget-making and policy power, has largely entrusted the UNC system with pre- and in-service teacher training in the area of math and science. UNC, through its 15 Schools of Education, the NC Mathematics and Science Education Network and the NC Teacher Academy, administers millions of dollars of pre- and in-service teacher training – this does not include additional millions of dollars for new teacher support and regionalized educational consortia which also provide training.

Because these programs have been added to UNC, SDPI, and elsewhere in a piecemeal fashion, accountability for the programs looks like this:

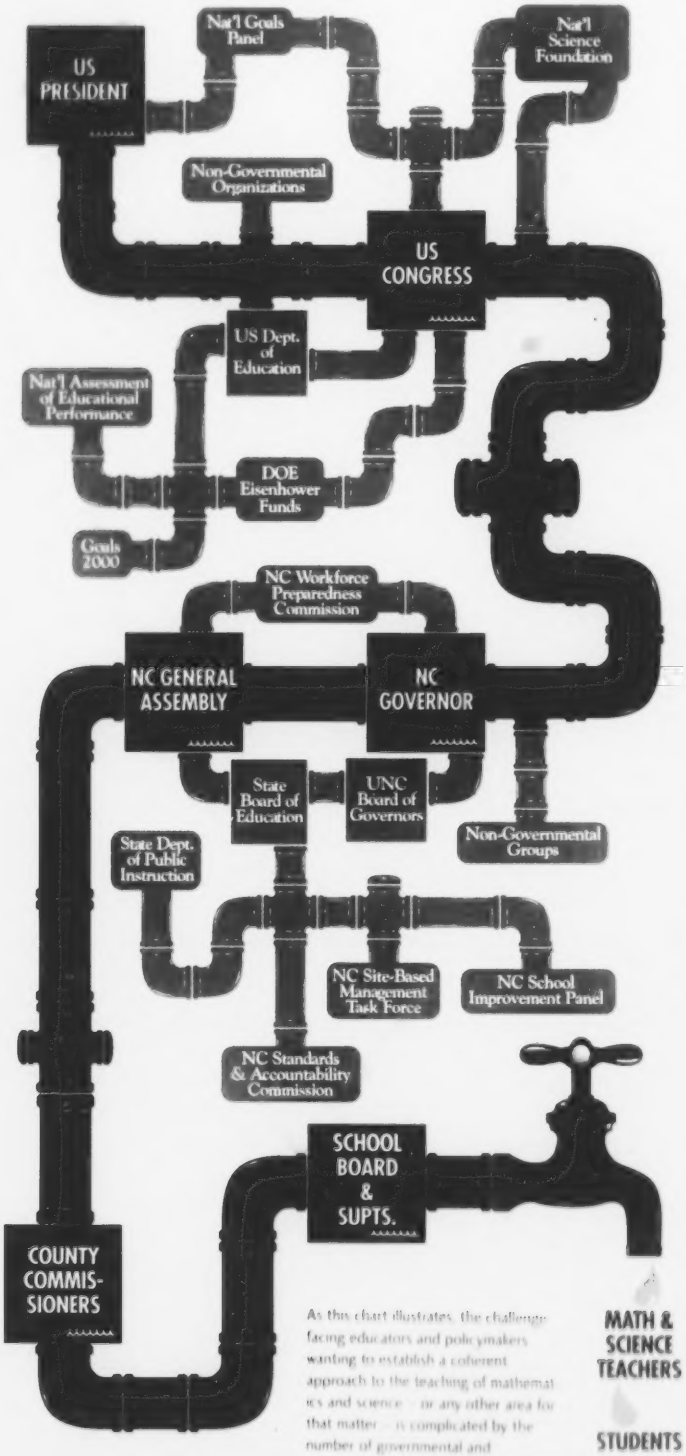
- The 15 Schools of Education are accountable to their college campuses; it took the Forum Study Group, for instance, weeks to determine exactly what the requirements were for mathematics and science education majors on different UNC campuses. There is no standard beyond the number of credit hours required. A student graduating from NCA&T will have had a different route to teaching math or science than one from UNC-W.
- The NC School of Science and Mathematics is governed by an autonomous board of trustees. UNC has no control over the funds appropriated to the school for long-distance learning being provided to K-12 schools – nor, for that matter does the State Board of Education which is held accountable for the performance of the schools for which the School of Science and Mathematics is providing services.
- The UNC Mathematics and Science Education Network, in similar fashion, is largely autonomous, reporting neither to the UNC General Administration, nor to Schools of Education, nor to the State Board of Education. Instead, the Network falls into a category called "inter-institutional programs" for which accountability falls to the Provost of UNC-Chapel Hill where the program is based.
- The North Carolina Teacher Academy has even less direct accountability to either the UNC system or to the State Board of Education. The Academy has its own Board of Trustees to which it is accountable; its funding, however, flows through the UNC General Administration which has no say over its program priorities or performance review. The State Board of Education, accountable for the performance of the teachers served by the Teacher Academy, also has no control over the Academy's priorities and programs.

Many who have examined needs in the area of mathematics and science agree that teacher education is the key to improvement. Ironically, while the State Board of Education is being held accountable for gains in mathematics and science, it has little to say about how millions of state and federal dollars are used to improve mathematics and science teaching; nor, for that matter, does the UNC system which administers the money.

If the Educational Cabinet wants to embrace better student performance in the area of mathematics and science as a shared goal with the State Board of Education, it must begin by making a candid assessment of accountability lines. If UNC is responsible for administering the bulk of teacher-training funding, it should share accountability with the State Board of Education – however, only if it is given the authority to oversee and evaluate how well dollars are being spent, which is not the case today. If the State Board of Education is to be solely accountable for student performance gains in math and science, it must be given more authority to align priorities and programs of groups which currently control training resources.

The Public Policy Pipeline

Impacting Policies and Practices in Mathematics and Science



As this chart illustrates, the challenge facing educators and policymakers wanting to establish a coherent approach to the teaching of mathematics and science — or any other area for that matter — is complicated by the number of governmental and non-governmental groups which impact educational laws and regulations.

US President
- Proposes annual budget including funding for the US Dept. of Education, NSF, etc.
- Can use the "bully pulpit" to advocate educational change (i.e., Goals 2000).
- Appoints officials (such as the US Secretary of Education) who have an impact on math and science issues.

US Congress
- Budget approval power.

National Goals Panel
Part of Goals 2000 initiative of former President Bush and Clinton working with the nation's governors.
- Establishes voluntary national educational standards.

The National Science Foundation
Established by Congress to strengthen US in math and science.
- Currently funding Statewide Systemic Initiatives aimed at changing state policies and practices in math/science instruction.

Non-Governmental Organizations
National Council of Teachers of Mathematics
National organization of public school and higher education teachers of mathematics.
- Devised and proposed national standards for math. All/major portions are being embraced by states including NC.

National Science Teachers Association
- Similar in role to National Council of Teachers of Math.

National Academy of Science
- Attempting to build consensus on national standards for science.

US Department of Education
- Proposes educational priorities to President.
- Involved in the national debate around standards and assessment.
- Uses federal educational funds as leverage for (i.e., competitive grants to states, innovative project funding).
- Can grant states waivers over federal regulations.

DOE Eisenhower Funds
Special training funds designed to improve quality of math/science teaching.
- Fund guidelines control flow of dollars at state level.

National Assessment of Educational Performance
- Developing national tests designed to give national standard benchmark for performance.
- Administering national tests in math/science; NC voluntarily participating.

Goals 2000
- Administering state grants to help states reach goals.
- Attempting to align national resources to accomplish goals.

Governor
- Proposes annual budget to General Assembly (including new education initiatives).
- Uses "bully pulp..." to advocate new initiatives (i.e. BEP, national certification standards, Smart Start, etc.)
- Appoints members to State Board of Education.

NC General Assembly
- The final word on budget approval and enactment of state education policy.

NC School Improvement Panel
- Charged with developing strategy to help state reach its goals, including goal of being first in math/science.

UNC Board of Governors
- Administers a university system which includes 15 schools of education.

State Board of Education
- Dictates licensure standards, curriculum expectations, assessment instructions, accountability standards, length of school year/day, regulations on expenditures, text books (both establishes and grant waivers), and use of in-service funds.
- Board waiver or regulation power over issues like: teachers out-of-field, use of time, etc.

NC Workforce Preparedness Commission
- Advocates for Tech Prep and application-based curriculum in math/science.

Non-Governmental Groups
- NC Council of Teachers of Mathematics
- NC Science Teachers Association
- NC Association of Educators
- NC American Federation of Teachers
- Professional Educators of NC
- Association of School Administrators
- Tarheel Principals Association
- NC PTA
- NC School Boards Association
- Public School Forum
- Education: Everybody's Business Coalition

NC Site-Based Management Task Force
- Advocates for building-based control over in-service training dollars, technology funds, as well as funds for materials, supplies and textbooks thereby having direct impact on math/science decisions at building level.

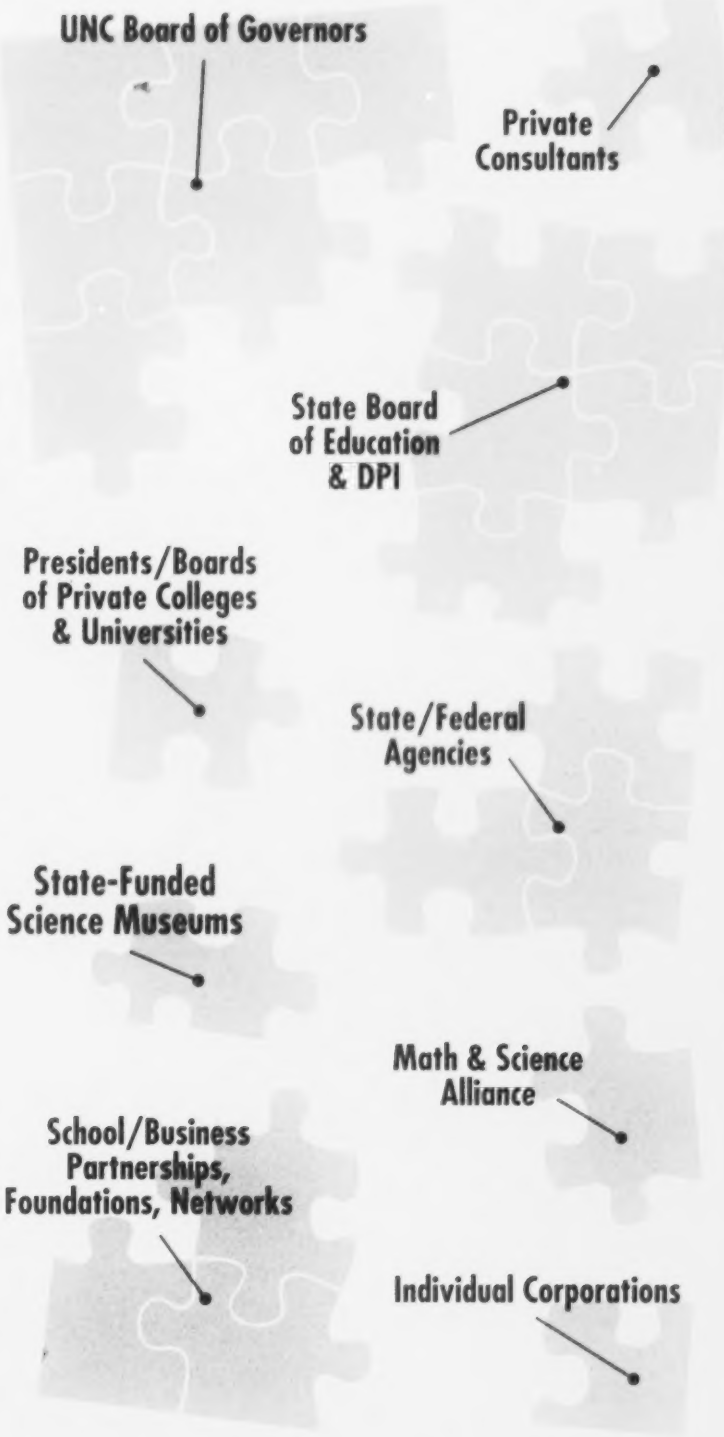
State Department of Public Instruction
- Responds to requests for assistance.
- Monitors student performance.
- Aligns curriculum goals and assessment practices.
- Provides information to local school systems.
- Conducts regular accreditation inspections on college campuses to determine program approval.
- Grants certification to teachers.
- Responsible for communication between public schools and colleges/universities.

NC Standards and Accountability Commission
- Charged with developing a new and rigorous set of curriculum standards for NC.
- Advocates covering much less curriculum content in areas of math/science.

County Commissioners
- Controls local school spending.

Local School Boards and Superintendents
- Sets instructional priorities.
- Determines expenditure of funds.

The Teacher Preparation Puzzle



UNC Board of Governors

- Administers 16 campus systems. System includes 15 schools of education, the Principals Executive Program and the newly created Teacher Academy

Boards/Presidents of Colleges/Universities Set budget and resource priorities, oversee schools of education and math/science depts. which prepare teachers

NC Mathematics & Science Education Network Coordinates multi-campus network with focus on staff development in math/science, conducts summer teacher training program, assesses/allocates federal Eisenhower funds earmarked for teacher training initiatives emanating from colleges/universities

NC School of Science & Mathematics Conducts summer training programs for teachers, has outreach programs with local school systems, is developing long-distance learning capacity for students which could play major role in staff development; governed by autonomous board

NC Teacher Academy Major summer training provider

Principal Executive Program Provides training/staff development for principals/school superintendents

Schools of Education Establish entrance/graduation requirements, determine dept. priorities resource allocation and teaching philosophy, monitor student teaching process, responsible for interfacing with math/science depts. enrolling future teachers

Presidents/Governing Boards of Private Colleges/Universities

The 32 colleges which are certified to prepare teachers are networked by the Independent Assoc. of Colleges & Universities but all of 32 are highly autonomous in regard to admission, graduation standards, budgeting, goal setting, etc.

Education and Mathematics/Science Depts. Set priorities, determine educational practices, oversee student teaching experiences, allocate resources based on priorities

Math & Science Alliance

NSF funded organization

- Provides training in math/science

State Board of Education & DPI

- Proposes in-service development funding level in annual budget
- Sets teacher prep program approval standards for colleges/universities
- Evaluates teacher training programs
- Determines licensure standards for teachers/administrators

Federal Eisenhower Funds Reviews local school system proposals for math/science training, distributes $5,169,342 of federal funds to local schools

Regional Technical Centers Provides training on request, brokers resources to local schools, acts as communications link between the State & local schools

Initial Licensure Program for Teachers Sets mentoring and support standards for local schools, provides training for mentors of new teachers

Program Specialists Within DPI

Provides training on request to local teachers, broker training resources to schools

Private Consultants

- Provide local training

State & Federal Agencies

Agric. Extension Services & USDA Extensive training programs

NASA Conducts teacher training programs in space/technology

Forestry Depts. & EPAs Conduct teacher training

School/Business Partnerships, Foundations, Networks

- Subsidize and/or provide teacher training experiences

Individual Corporations

- Support/provide teacher training in science/technology

Piecing together the math and science teacher preparation puzzle: a critical challenge if North Carolina wants to make dramatic gains in student performance in mathematics and science.

Training Opportunities & Lost Opportunities

"If I could do one thing to improve mathematics and science, it would be to change the way mathematics and science are taught at the college level. In North Carolina, if UNC and North Carolina State don't change the way prospective teachers are taught, others will not feel they have permission to change." – Iris Weiss, a consultant to the National Science Foundation who is now evaluating mathematics and science progress in North Carolina

"What I learned in my college teacher preparation program was not how to teach; I didn't learn anything about teaching until I taught." – Louis Gotlib, a former North Carolina Teacher of the Year who teaches science in Granville County

Throughout this study, teacher training came in and out of the conversation as regularly as oxygen comes in and out of one's lungs. Regardless of which mathematics or science problem facing North Carolina was under discussion, sooner or later teacher training surfaced as a key ingredient to finding solutions. That was especially true in areas like:

- Altering teaching practices to provide students with more opportunities to apply mathematics and science concepts to real-life situations.
- Giving teachers the skills needed to integrate mathematics and science instruction with other course work.
- Providing teachers the new set of skills needed to take advantage of long-distance learning opportunities and new technologies rapidly becoming available.
- Developing better ways to assess whether young people can apply mathematics and science concepts to practical situations.

Because the need for more and better teacher training appears to be the basic building block for a stronger mathematics and science program, this chapter examines the training problems that surfaced during the study.

When training needs were discussed, the discussions typically focused on two discrete, but closely related, problems. First, there is a widespread perception that college students being prepared to teach mathematics or science are not being given the tools they need to bring about dramatic improvements. Criticism of college preparation tends to focus on:

1. The tendency of most college faculty members to rely heavily, if not exclusively, on the lecture approach to instruction, instead of modeling hands-on, inquiry-based learning techniques that prospective teachers could emulate throughout their teaching careers.
2. The lack of collaboration between schools of education responsible for preparing teachers and Mathematics and Science Departments which provide most of the science and mathematics course work for prospective secondary teachers majoring in mathematics or science.
3. The slowness with which most colleges and universities are integrating new technologies into teacher preparation programs.
4. The heavy focus on advanced courses in mathematics and science and the fairly limited number of programs giving prospective teachers hands-on opportunities to experiment with different teaching techniques before entering the teaching profession.
5. The limited exposure to mathematics and science coursework required of elementary teachers who carry the burden of sparking young people's interest.
6. The sparsity and quality of school-based experiences in teacher preparation programs.

A study of North Carolina Teaching Fellows validated these criticisms. Beginning high school teachers with a major in mathematics or science felt well prepared in terms of course content, but under prepared in teaching techniques and strategies. On the other hand, many elementary teachers felt well prepared in teaching techniques, but woefully unprepared in content preparation, especially in the area of science.

Ironically, this perceived weakness of college preparation programs is not a perception confined to beginning teachers. Recent studies from groups like the Holmes Group, a consortium of the nation's leading Schools of Education, echo these perceptions. There is a broad and growing consensus that Schools of Education are not preparing new teachers to focus on the application of learning, but rather the coverage of material; the same consensus exists around the need for Schools of Education to give prospective teachers more exposure to working directly

Blurred and confused accountability lines prevent the State from creating a coherent system of training for teachers of mathematics and science.

with young people, to introduce technology into teacher preparation programs and to model teaching practices other than the lecture method.

Change, however, comes slower than the process of building a consensus around what should be or could be done. While some Schools of Education within the UNC system, most notably East Carolina University's teacher preparation program, are undergoing radical restructuring to meet today's needs, such examples are few and far between.

The second problem in teacher preparation relates to the quality and quantity of training available to teachers already on the job, the area of "continuing development."

As noted earlier, teachers of mathematics and science have extensive opportunities for in-service training available through a variety of training providers. There is, however, no systematic, coordinated in-service program available for teachers; instead:

- In-service training at the school system level varies dramatically depending on the size and resources of the local school system.
- The bulk of in-service training is "one-shot;" a one day training session with little, if any, follow-up.
- There is no natural progression of training for new teachers. Typically, mathematics and science teachers will attend the same in-service training regardless of their needs or abilities. It is difficult to find a school system that has a planned developmental program of in-service training that systematically lets teachers advance as their needs change.
- There is no central clearinghouse resource for in-service training. Instead, some systems rely on local colleges and universities for trainers; others call on the State Department of Public Instruction; still others use private consultants. While the quality of in-service training is largely dependent on the quality of the trainers, the selection of trainers tends to be very much people and relationship based; there is little or no attempt to ensure a baseline of quality control.
- Millions of dollars of state and federal government and private sector funds are spent each summer on enrichment training for teachers in mathematics and science. Again, there is no coordinated system to ensure that those who need training are receiving it or that the training being offered is aligned with state needs and goals. Instead, many of the training opportunities are filled on a "first come, first served" basis.
- For training to make a difference, it needs to be near at hand. The slimming down of government agencies means mathematics and science resources which formerly were close at hand in SDPI Technical Assistance Centers have disappeared and nothing has been put in their place, a particularly vexing problem for the State's most geographically isolated counties – counties which are among the lowest performing in mathematics and science.

Problems related to a lack of coordination or systems-thinking would be formidable if they were the only training problems that needed attention. As formidable a problem, however, are the blurred and confused accountability lines that prevent the State from creating a coherent system of training for teachers of mathematics and science.

Eisenhower Funds Illustrate Accountability Tangle Between State & Federal Funds

Because over $5 million federal dollars are spent each year to support in-service training of mathematics and science teaching, the Study Group looked carefully at how North Carolina schools and colleges spend Eisenhower Funds, funds appropriated to support in-service training and development of mathematics and science teachers.

When the State Department of Public Instruction describes North Carolina's use of Eisenhower Funds in the public schools (roughly 75% of Eisenhower Funds are used in K-12 schools; the balance goes to higher education). They note that North Carolina has one of the nation's best programs. "Best" means that all of North Carolina's public schools qualify for Eisenhower Funds and very little of the funds revert back to the federal government. In short, the State's K-12 schools get and spend the federal money.

The questioning then moved to whether North Carolina ever looked at what high-performing schools do with the funds as opposed to what low-performing schools do. Study Group members were curious to know if there were lessons to be learned about how the federal funds were spent. Again, the answer was "no;" the State has never formally studied how the funds are being spent to see if there is a correlation between improved performance and the use of Eisenhower training funds.

This line of inquiry is not cited as an indictment of the SDPI; rather, it is cited to illustrate the degree to which today's accountability systems, especially at the federal level, are focused on numbers served, not numbers served well.

The Study Group also inquired about the State's ability to focus the use of Eisenhower Funds or to require school systems to use them in promising ways. Because of federal guidelines, states can "suggest" that school systems refocus their dollars; they can not require them to use their dollars in a particular way. That is also a frailty of many governmental programs. Accountability rests upon spending money within proscribed guidelines, not upon spending money to do effective things.

One of the recommendations later included in this Study Group report calls on the State Board of Education to ask the U.S. Department of Education for a waiver which would allow the Board to shape how the Eisenhower program is used. Think of the possibilities:

- The State could look at high-performing schools to see if best practices regarding the use of Eisenhower training dollars could be found; those best practices could provide a framework within which low-performing schools could be required to operate if they wanted to continue receiving funds.
- The State could earmark more of its federal training dollars to the school systems that needed the most help.
- The State could require that low-performing schools work with the State Department of Public Instruction to design more effective programs.
- The State could further require a formal annual assessment of the effectiveness of local training programs before additional funds were released.

While the federal government could deny such a request, it would be better to have asked and been denied than continue to have millions of unaccountable federal dollars flow through the State each year with virtually no assurance they are spent in such a way that student performance in mathematics and science improves.

Today's accountability systems are focused on numbers served, not numbers served well.

It's a Matter of Time

Training, as stated earlier, was the most frequently cited need if North Carolina is to reach new levels of excellence in the teaching of mathematics and science. Virtually every discussion of training, however, ended with a discussion of time, or the lack of it.

More and more observers of America's schools are identifying time as the culprit which prevents our schools from being all that they could and should be. Teachers do not have the time needed for quality in-service training; for planning challenging lessons; for giving students personal attention.

For the State to adopt a vision of excellence in mathematics and science, time, or the lack of it, is a problem which must be addressed.

In the seventies, North Carolina's General Assembly broke new ground when it recognized the need for staff development and planning. A law extending every teacher's contract twenty days beyond the 180 student instruction days made North Carolina the first state to acknowledge the pressing issue of time.

North Carolina teachers were also the first in the nation to accumulate vacation days thanks to legislation passed in the early eighties. Ironically, this legislation virtually negated the potential training and planning benefits of the extended teacher contract. The law granted teachers earned vacation days, but it specified that vacation days could only be taken on the teacher work days. What was intended to be a real benefit for teachers, virtually destroyed the planning and in-service value of teacher work days. School systems can only "protect" roughly six or seven of the teacher work days *(i.e., make them mandatory work days on which vacation cannot be taken)*. Most of those days coincide with opening and closing school activities and their value for planning or in-service training is marginal.

Thus, most school systems must find additional funds to pay teachers for work days in the summer. Those who have the resources squeeze planning and training in at the end of the school day, hardly a time when teachers can take best advantage of the learning opportunities.

More and more individuals and groups, including the Forum, have concluded that without extending the teacher year into the summer months, it will be difficult, if not impossible, to create the kind of in-service training programs needed to equip today's teachers with tomorrow's skills.

While discussing time as a culprit, it is important to realize that the lack of time not only limits the ability of teachers to plan and to freshen their skills; it also steals away precious days of instruction from young people across North Carolina.

It has been twelve years since the nation's "school reform" fervor began, when the publication of *A Nation at Risk* sounded the alarm bell. During that time, study after study has bemoaned the shortness of America's school year. While young people in the United States attend school 180 days per year, their counterparts in other industrialized countries routinely attend school approximately 210 days per year. By the time a student in Japan graduates from high school, they will have attended school for nearly the same amount of time an American student would have taken to earn a college degree.

	Days in School Yr.	Hours Homework Per Week	Homework During Summer/ Vacations	Avg. Absences Per Year
Japan	243	19	Yes	3
China	240	26.5	Yes	5-8
Germany	240	4	No	6
Russia	208	8-14	Yes	6-8
Canada	195	7-10	No	–
England	192	8-10	No	–
U.S.	180	3.8	No	20

As the chart above illustrates, the shortness of the American school year gives other nations a competitive edge that many, including the Public School Forum, contend will never be made up if we cling to the 180-day school year.

As if the shortness of the instructional year were not enough, North Carolina students are also hampered by the limitations of school schedules, especially at the secondary level.

For a mathematics or science teacher to truly focus on application of knowledge, not simply the coverage of material, 45-minute class periods pose a formidable barrier. In science especially, it is almost impossible to set up and complete an experiment centered around the application of knowledge to a real life problem in 45 minutes.

More and more high schools are adopting what is called "block" or "4 by 4" scheduling which results in 90 minute blocks of time for basic course work; in those schools, initial feedback indicates that the additional time available for instruction has the potential to pay real dividends for student performance. In the meantime, North Carolina's students are limited by both the number of days of instruction and the number of hours of instruction offered daily.

Thus, the issue of time hobbles young people in North Carolina in two ways. First, the shortness of the school year means that young people in countries such as Japan and Germany will have had four years more of instruction in mathematics and science by the time they graduate from high school. Second, the limitations of the typical school schedule virtually defies organizing courses around problems and experiments designed to challenge students to apply knowledge, not simply cover material.

For the State to adopt a vision of excellence in mathematics and science, time, or the lack of it, is a problem which must be addressed.

Communication or the Lack of It

Question: If the State Board of Education changed its mathematics or science assessment practices, how would the mathematics or science faculty at the 47 public and private colleges training teachers get the news?
Answer: Slowly, if at all.

Question: When school systems are notified that there are paid summer enrichment opportunities available for teachers of mathematics and science, how will the mathematics and science teachers receive the news?
Answer: It varies dramatically. In some districts, they might receive the news quickly; in many, the deadline for applying for summer enrichment programs has passed before teachers find out that opportunities exist.

Question: How often does the State convene coordinators of mathematics and science to make sure they understand and are part of the process?
Answer: Many school systems used to employ full-time coordinators of mathematics and science; because of central office cut backs, only six do today. Also, the SDPI used to have full-time mathematics and science coordinators in regional offices; because of state agency cut backs they no longer have them. The answer is that such meetings are largely a thing of the past.

Question: Does the State convene all of the people and organizations involved in delivering in-service training to mathematics and science teachers?
Answer: No.

Question: Does the State attempt to convene either the Deans of all 47 public and private teacher training Schools of Education or their mathematics/science instructional coordinators to keep them abreast of state needs and goals?
Answer: No

All of these questions and more were posed to officials of the State Department of Public Instruction, to classroom practitioners, to college faculty and others in the search for a center of coordination for mathematics and science.

As the responses indicate, to say that there is a communications problem between the State and those responsible for improving mathematics and science instruction is to understate the issue.

A focus group conducted with award winning mathematics and science teachers from North Carolina's public schools underscored the problem. When asked to describe the communications flow from the State, they described a haphazard system that is totally dependent on local school systems having an efficient routing system. Not atypically, the State communicates information related to mathematics or science to the local School Superintendent; the Superintendent, or often his/her secretary, decides who in the front office should receive the mail. That person, or his/her secretary, decides whether to route the communication to building principals, grade level team leaders or department chairs; they, in turn, decide who has a "need to know." Not surprisingly, the State can say, with justification, that "we sent the information." Frequently, however, the information never reached the people intended to receive it; or, it arrived too late to be of value.

An award winning science teacher described the State's mathematics and science communication system as a "trickle down process, but the trickle rarely trickles all the way down to a first grade teacher's desk."

It almost goes without saying that if there is to be a coherent statewide focus in mathematics and science, a communications system is central to building that coherence. Presently, it appears that the system needs to be built from the ground up because there is no foundation in place upon which a communication system can be built. Worse yet, as previous chapters illustrated, many of the groups or individuals that would be key to building a coherent system have no accountability or responsibility to respond to the State Board of Education if it chose to communicate, convene or coordinate.

Equity Issues and Rethinking the Basic Education Program

When looking at student performance in mathematics and science, one cannot help but be struck by the enormous differences between the performance of different school systems and different groups of children.

The starkest difference in achievement scores in mathematics and science is found between African-American and white students. A related issue, which helps explain such differences, stems from where students reside. As the charts below show, the "luck of the draw" – or, more precisely, where a child happens to live in North Carolina – is a strong predictor of how well he or she will do on an SAT test when nearing graduation.

It must be stated that the State is attempting to address the educational problems associated with socio-economic differences between young people. Programs like Smart Start, at-risk initiatives and mentoring programs are all designed to give children from lower-economic homes a better chance. However, State funding policies continue to turn a blind eye toward the lessons that can be learned from student performance numbers.

With the exception of additional funding for low-wealth and small school systems *(equal only to 1.2% of the State's public school expenditures)* school funding assumes that all counties were created equal. However, eight annual Forum studies of school finance have dramatized how unequal North Carolina's 100 counties are when it comes to their ability to support excellence in schools.

Ironically, the State's Basic Education Program, intended to provide a foundation level of funding which ensures all students a basic education program, stands in the way of every student reaching new levels of excellence in mathematics and science as well as other subject areas. It does not fund course work that is, by today's employment standards, basic and essential. Consider the language in the following chart taken from State programs defining what is covered in the Basic Education Program.

If the State's goal is to seek excellence in the fields of mathematics and science, this list of non-basic, non-funded courses speaks for itself. Predictably, communities which can afford to support these types of course offerings are doing better than those which cannot.

The following electives are listed as suggestions. They are not part of the Basic Education Program, and they have not been factored into the costing out of the Program. Local administrative units which choose to offer these electives are expected to do so at local expense.

Mathematics

Trigonometry	Computer Mathematics
Advanced Algebra	Analytical Geometry
Calculus	Probability & Statistics

Science

Advanced Biology	Geology
Advanced Chemistry	Field Botany
Anatomy & Physiology	Environmental Studies
Applied Science	Advanced Physics
Astronomy	Independent Study

Source: The Basic Education Program for North Carolina's Public Schools (1994), p. 50.

On the other hand, communities which can barely afford to keep school buses running and buildings in decent repair, are not offering them and it shows – consider the local funding capacity of the ten school systems scoring lowest on SAT scores when compared to those scoring highest.

If the State sets out to be excellent in what it does in the area of mathematics and science instruction, it must address a system of funding schools which increases the likelihood that students in the State's neediest systems will be exposed to fewer, less challenging courses than students living elsewhere.

Highest '95 SAT Scores

School System	1995 SAT Score	1993-94 Local Per Pupil Expense
Chapel Hill	1060	$2,176
Asheville City	946	2,080
Wake	938	1,274
Watauga	923	804
Jackson	915	709
Hickory City	912	1,032
Mooresville City	911	857
Clay	911	480
Buncombe	910	1,020
Burlington City	908	1,102
Average**	933	$1,305

Lowest '95 SAT Scores

School System	1995 SAT Score	1993-94 Local Per Pupil Expense
Hyde	736	$1106
Robeson*	732	480
Anson	727	709
Washington	713	448
Columbus*	711	562
Northampton*	704	559
Halifax**	689	536
Montgomery	689	590
Hertford	689	689
Weldon City*	676	1,124
Average**	707	$781

* LEA meeting Warning Status criteria in 1994. ** LEAs meeting Low Performing criteria in 1994. *** Figures are unweighted. Source: NC State Department of Public Instruction

Harnessing External Resources

As noted earlier, North Carolina has a wealth of resources already attempting to strengthen the teaching of mathematics and science in the public schools. Included among them are North Carolina's School of Science & Mathematics, private foundations, corporations and corporate foundations and a host of non-educational state and federal agencies, departments and museums.

A survey of these external resources and an accompanying survey of school systems, however, uncovered disturbing findings:

- Many school administrators view externally-supported initiatives as "one-shot" or one-time programs because of funding. When external support ends, typically, the projects ends.
- Providers of outside resources frequently believe that their support will lead to new teaching approaches and programs being replicated throughout school systems. That is too rarely the case. More often, within one or two years of an externally-supported program coming to an end, there is little evidence that it ever existed.
- Often, external supporters propose programs which are commendable in their own right but not tightly connected to school system goals. External support groups wanting to align their work with State goals would be hard pressed to know where to begin; the State does not communicate its goals and strategies to external providers much less provide suggestions on how external support could enhance the State's drive for excellence in mathematics and science.

To address that problem, the Study Group is issuing a separate publication aimed at foundations, corporations and external support groups. In that publication it is suggested that external resource groups align their efforts with local school system goals. It is also suggested that research and development efforts funded by external groups should not begin until there is a written commitment from top school officials and school board members to incorporate and replicate successful programs.

Beyond that, the State should develop a formal communication link to external foundations and corporations. That link could be through existing organizations. It could be through convening major private supporters of school programs. Linkage, however, is critical if alignment of resources is to occur.

One resource has the potential to make an enormous contribution to North Carolina's public schools and it deserves further mention. That is the North Carolina School of Science and Mathematics (NCSSM).

The General Assembly in 1994 appropriated funds to NCSSM to develop long-distance learning capacities for students that have enormous potential – potential not only to enable the State to send quality course material to schools across the State, but potential to enable the State to transmit quality in-service staff development to teachers from one end of North Carolina to the other.

The State, by aligning NCSSM more closely with the State Board of Education, could address several problems at one time. NCSSM could provide a number of services to public schools. For instance:

- NCSSM could be a center for evaluating mathematics and science software available for teachers.
- NCSSM could work with the SDPI and develop a bank of teaching strategies aligned with the State's goals for mathematics and science.
- NCSSM could work with the SDPI to harness technology in a systematic way both for instruction and for staff development.
- NCSSM could provide a residential site for in-service teachers to learn new approaches to science, math and technology instruction year-round as these innovative approaches are developed and tested.

Such an alignment could enable the State Board of Education, working hand in hand with NCSSM, to bring badly needed services to public schools at little or no additional cost to taxpayers.

Harnessing Resources and Lost Opportunities

Noted earlier was the fact that fifteen states have looked to NCSSM as a model when they established similar flagship schools for mathematics and science. Not noted was the fact that schools and colleges in thirty-seven states are using NCSSM's pre-calculus textbook. This summer 49 teachers from 16 states came for training in the NCSSM pre-calculus approach.

Ironically, North Carolina has not adopted NCSSM's pre-calculus textbook for public schools. Why? Textbooks for pre-calculus are on a seven-year adoption cycle established by the SDPI and the production of NCSSM's material missed the last deadline.

Local Decision Making and State Goals: Avoiding a Collision

The shift toward providing local communities and school buildings with more decision making authority is moving rapidly at the state and federal level. While local control is a siren song for school reformers and politicians alike, there are some unintended consequences that should give policymakers committed to making North Carolina a leader in mathematics and science reason to pause. Consider:

- Recent changes in the federal government's Eisenhower Program have made funds formerly earmarked for mathematics and science in-service training eligible for use in other subject areas ranging from art to geography. Many expect that loosening of regulations to bring with it an immediate decrease in focus on mathematics and science. As a former North Carolina Teacher of the Year said, *"We've (i.e., mathematics and science teachers) had extra training money for years; now, other teachers feel it is their turn."*
- A good example of the impact of such policy directions was provided when the State gave schools the latitude to spend $7 per child of funds formerly earmarked for mathematics and science supplies on other areas. Within a matter of years, science department budgets in rural high schools like Granville County's dropped from $7 per child to today's $2 per child. For a science class with 26 students, a budget of $182 is now $52 for supplies and materials. The kind of supplies needed if students are to perform real life experiments are, not surprisingly, less and less available.

For the State Board of Education, these examples raise serious questions about site-based decision making. Consider:

- What is the proper balance between the State maintaining the ability to establish goals and priorities while enabling local schools to have a real voice in decisions?
- If, for instance, it is clear that teacher training in the areas of mathematics and science is the key to progress, can the State relinquish all of its authority to shape local in-service programs funded by State dollars?

Today, the debate around State control and local control tends to be seen as an either/or proposition – either the State controls or local schools control. Perhaps it is a question of finding the proper balance between the two. Where the State has a real priority, it should keep the authority to establish a framework within which schools would have control. If there is no framework, no clear State priority, disconnectedness and unaligned resources can be expected.

Bringing It All Together

The previous chapters have described a situation in which disconnectedness, a failure to communicate, blurred lines of accountability, and a failure to marshal the wealth of resources have lessened the likelihood that substantial progress will be made in the areas of mathematics and science.

Today's state of affairs, however, can be changed and changed for the better if the goal of reaching new standards of excellence in mathematics and science instruction were to be embraced as a priority by top policymakers and educational officials.

The following pages will describe what could happen if the improvement of instruction in mathematics and science were to be elevated to a priority status in North Carolina.

The Potential Role of the Education Cabinet

In an effort to create a more coherent educational program, the General Assembly mandated that the leadership of the public schools, the community colleges and the university system begin meeting together with the goal of creating a more efficient state system of schooling.

Governor Hunt, building on that mandate, created an Education Cabinet which the Governor chairs. That Cabinet, which includes the top officials from the State's public school, community college and university systems, as well as the Association of Independent Colleges and Universities, is now meeting regularly and is beginning to demonstrate in areas like technology the potential benefits of collaboration between the educational systems.

For excellence in mathematics and science instruction to become a norm in North Carolina, the Education Cabinet is key. It could perform roles like:

- Establishing a Mathematics and Science Operational Council which draws on the expertise of all. Given the public schools primary accountability in student performance improvement, the Council could be chaired by a representative of the State Board of Education; or, given the need for true collaboration, the Council could be co-chaired by top level officials of all four systems. Whatever the structure of the Council, it will not succeed unless top-level officials are assigned to coordinate its work and be accountable for its success.
- Assessing today's confused accountability lines and recommending a plan which would marshal all of the state and federally funded resources in the areas of mathematics and science. Such a plan would delineate roles and responsibilities for the three levels of education and, where necessary, suggest to the General Assembly an altering of today's accountability lines to bring government-funded resources into alignment with the goals of the State.
- Applying research and accountability standards to all state- and federally-funded mathematics and science resource providers. Currently, there is little independent research done to assess the effectiveness of mathematics and science resources. The Education Cabinet could annually assess the degree to which state- and federally-funded resources are in alignment with State goals, contributing to State goals and effective in helping the State reach a new level of excellence in mathematics and science instruction. Even if neither the State Board nor UNC Board of Governors can control the use of state and federal resources in mathematics and science, they could perform an invaluable service by informing the General Assembly and the federal government about the degree to which tax dollars are aiding North Carolina's pursuit of excellence.
- Charging the Mathematics and Science Operational Council with performing the role of "traffic cop" for resource allocations. What is the proper role, for instance, of the nationally-renowned North Carolina School of Science and Mathematics? How should the UNC Mathematics and Science Education Network and the Teacher Academy pool resources to ensure the most effective delivery of summer training opportunities for mathematics and science teachers? At the moment, no organization is empowered to assign responsibilities, align resources and avoid duplication.
- What can be learned from the remediation data gathered by Community Colleges and Universities and Colleges? Could there be a road map to excellence already in the data measuring how well or poorly high school graduates are performing? Combining the resource capacity of the systems could enable North Carolina to discover new paths to excellence in mathematics and science.
- Most importantly, the Education Cabinet could, by establishing accountability benchmarks and including progress in the area of mathematics and science on each of its meeting agendas, elevate excellence as a real goal for the schools of North Carolina. The axiom what "is checked" gets done applies to government as well as to business. The Cabinet must establish goals and keep checking if the State is to make progress.

Dramatic Change Hinges on the Governor

The following suggestions to the Education Cabinet will mean little, if anything, if the Cabinet is not exhorted to elevate the issue of mathematics and science instruction to a matter of utmost urgency. Because of the complexity of issues – accountability lines, coordination, communication, federal and state jurisdictions – dramatic improvement, of necessity, calls out for strong leadership.

Governor Hunt's decision to Chair the Education Cabinet is an indication of the importance the Administration places on education. His decision to have the Cabinet staffed by the Governor's personnel further indicates the degree to which he values progress in education. His decision to invite independent colleges and universities to be part of the Cabinet is a recognition on his part of the need for collaboration inside and outside of government.

This proposed road map for improvement in mathematics and science could, if successful, point to an approach which could be applied to any area of the education continuum.

The matter, however, hinges first on leadership and second on follow-through. A former Chairman of the State Board of Education, perhaps said it best when he noted: *"If this is to succeed there is only one person in North Carolina that can say, 'This journey is not optional; we're all going together.' That person is the Governor."*

Signaling a seriousness of intention is one matter; ensuring adequate follow-up is another. Earlier in this document it was recommended that the State Board of Education ask the federal government for waivers giving it far greater latitude in aligning state and federal resources in the mathematics and science arena.

In like fashion, the Governor could look to the National Science Foundation's Systemic State Initiative effort underway in North Carolina for the resources needed to bring together a public/private collaboration aimed at improvement in mathematics and science. A collaborative state/federal approach to the problem would make possible a major initiative that doesn't require the creation of a new bureaucracy or the expenditure of additional tax dollars.

The existence of the Cabinet coupled with the already-in-place federal program designed to help states reach higher goals, present the State and the Governor with the opportunity to forcefully and effectively marshal state and federal resources.

Potential Roles for the State Board of Education

Turning to the State Board of Education, it, like the General Assembly, has enormous leverage because of the authority invested in it; specifically:

- The State Board of Education sets program approval standards that all 47 private and public colleges and universities must meet if they are to continue training prospective teachers. The ability to set standards that must be met gives the State Board enormous power to reshape college mathematics and science training preparation programs.
- In like fashion, the State Board of Education has the authority to establish accreditation standards for K-12 school systems. If mathematics and science instruction were to be elevated as a priority, accreditation standards could require schools to do more in areas like in-service development, school scheduling, interdisciplinary instruction, technology training and the like.
- The State Board also establishes curriculum expectations and assessment practices for which schools are held accountable. Many contend that today's assessment practices guarantee that little will change in classrooms. If, for instance, the State's testing programs for mathematics and science incorporated more and more assessment of application skills, the State would make an overnight impact on how both subjects were taught. As the superintendent of one of the State's largest school systems said during a Study Group meeting, *"What gets tested gets done."*
- State Boards of Education across the country have recently been encouraged to approach the federal government with waiver requests in situations where federal policies inhibit states from reaching their educational goals. North Carolina could request waivers from federally funded groups such as the National Science Foundation or the administrators of the Department of Education's Eisenhower program that would give the State Board the ability to ensure that federal funds are being used to advance State goals in mathematics and science. The worst that the federal government could do would be to reject such a request; at best, North Carolina could be a national leader in aligning state and federal programs. If North Carolina's State Board, working collaboratively with NSF and Eisenhower Fund officials, could align the expenditure of federal funds with North Carolina's mathematics and science goals, it could be a model for the nation.

26

- The State Board of Education could initiate regular written communications to K-12 and university faculty members in the mathematics and science arenas. Such communications could clearly communicate state goals, disseminate information about promising practices and close the information gap which exists today. This is especially critical in light of impending reductions of the SDPI's regional technical assistance centers formally charged with communications responsibilities.
- Finally, the State Board of Education should exercise leadership through convening all of the disconnected groups involved in mathematics and science instruction in the public schools. Associations representing mathematics and science teachers could play a much greater role in helping the State communicate to classroom practitioners. As noted earlier, external resources could be in much better alignment with State goals if the providers of those resources were brought together and given a road map of how their resources could most help the State reach a new level of excellence.

Potential Roles for the Community College System

- The Community College System could draw on its extensive body of information related to remediation needs of public school graduates entering the Community College System to help design an instructional road map public schools could use in designing a better system of instruction in the area of mathematics and science.
- The Community College System, which has been harnessing long-distance technology for instruction for some time, could collaborate with K-12 school systems in an effort to better harness technology both for instruction and for staff development.
- Community Colleges, especially those located in rural areas, could provide consortia of K-12 school systems a hub through which they could tailor local services needed to strengthen their mathematics and science programs.
- As Tech Prep programs are already demonstrating, community colleges and surrounding K-12 school systems could maximize resources by jointly developing applied math and science course work which could be offered to high school students at community colleges.

Potential Roles for the University of North Carolina

- UNC General Administration is conducting an assessment of the Mathematics and Science Education Network regarding its operation, organization, and governance. Those findings should become part of the overall mathematics and science plan jointly developed with the Education Cabinet to provide the most effective delivery of services, and avoid duplication within the UNC system.
- UNC, working with the other members of the Education Cabinet, should devise a system of evaluation that would ensure that teacher training resources are accountable, targeted to the State's areas of greatest needs and aligned with State goals.
- UNC, working with provosts, Deans of Schools of Education and Deans of Schools of Arts and Sciences should provide incentives to stimulate a much higher degree of collaboration between Schools of Education and Departments of Mathematics and Science throughout the UNC system. It should also conduct an assessment of current credit requirements and teaching approaches used in programs preparing prospective mathematics and science teachers for the public schools.
- UNC, working with the State Board of Education, should help create a communication system which would ensure a better flow of information about State goals in the area of mathematics and science between the State Board of Education and mathematics and science faculty members responsible for preparing prospective teachers.
- UNC, working with the Community College System and the public schools, should determine whether a combination of the Educational Consortia now housed at eight UNC colleges and universities could, in combination with community colleges and NCSSM, fill a mathematics, science and technology service delivery void left by reductions in SDPI's Regional Technical Assistance Centers and/or become centers of collaboration for regional consortia of public school systems attempting to reach new standards of excellence in mathematics and science.

Potential Roles for Independent Colleges and Universities

The 32 independent colleges and universities which have schools of education, as noted earlier, have recently been invited and have responded affirmatively to be part of the Education Cabinet through their coordinating organization, the Association of Independent Colleges and Universities. They offer the potential to make a major mathematics and science initiative even more powerful. They could:

- In tandem with state-supported colleges and universities conduct an assessment of the degree to which Schools of Education and Schools of Arts & Sciences programs and practices are in alignment with the State goals in the area of mathematics and science.
- Work with the Education Cabinet to devise a communication system which would include college faculty from the 32 schools of education as well as faculty preparing secondary education teacher candidates for majors in mathematics or science.
- Include their network of schools of education in discussions about making regionalized support services available to all local schools.

Potential Roles for the General Assembly

The General Assembly should embrace the goal of bringing North Carolina schools to a new level of excellence in the instruction of mathematics and science.

Toward that end, the General Assembly should work with the Education Cabinet in putting into place a system which aligns state and federal resources with State goals in mathematics and science; where necessary, alter existing accountability lines which impede alignment; support changes recommended by the Cabinet aimed at avoiding duplication and overlap of state resources. The Education Cabinet's involvement in educational reform will succeed due to major commitments and effective cooperation across traditional boundaries, not because of additional legislation. This cooperation should produce complementary and articulated services to North Carolina by constructing the "patchwork quilt" of educational excellence needed for all.

Finally, the General Assembly should scrutinize the degree to which existing school funding formulas, especially those of the Basic Education Program, and the shortness of the existing school calendar are impeding North Carolina schools from making greater strides toward excellence in the area of mathematics and science.

A Starting Point, Not a Final Solution

In offering these recommendations to policymakers, it is difficult not to go further and make many more suggestions.

Organizations including businesses, corporations and state and federal agencies (e.g. Agriculture, Forestry and state-supported science museums) which support mathematics and science initiatives, for instance, could form a Council to better coordinate their work. Associations of teachers of mathematics and science could be exhorted to contribute to a drive for improvement.

Such recommendations, however, are second steps and, ideally, would evolve out of a plan jointly framed by North Carolina's Education Cabinet.

The first step, of necessity, is for the State's top educational officials to elevate the teaching of mathematics and science to a priority status and to frame a plan which has the potential to move the State toward new standards of excellence.

Such a plan, if supported by the General Assembly, could start North Carolina down a path that could mark a turning point in the State's efforts to build a more effective system of schooling for its young people.

Thankfully, if top educational officials, exhorted to action by the governor, accept the challenge to bring all of the State's resources into alignment, there are valuable lessons to be learned from other states. Recognizing that the state of disconnectedness described in this report was typical of most State programs in mathematics and science, the National Science Foundation (NSF) concluded several years ago that it would take a bold initiative to bring about coherence and progress in the teaching of mathematics and science.

That led the NSF to initiate what they called a State Systemic Initiative (SSI) which had as its goals many of the same things that are recommended in this document; specifically the SSI urged states to:

Adopt comprehensive programs to bring coherence to teaching, training and accountability programs in mathematics and science.

Better marshal state and federal mathematics and science resources.

Move toward a focus on problem solving and the application of mathematics and science skills.

Address equity issues impacting mathematics and science performance among diverse groups of young people. There are lessons to be learned from the states in which the NSF's systemic initiative is making a difference; for instance:

- Greatest progress is occurring in states where policymakers and top educational officials have embraced improvement in mathematics and science as a priority.
- Efforts are much more successful when all the various stakeholders are involved and informed.
- Collaboration between the public schools, university systems and private resource providers is critical to the undertaking.

Given the nature of education, part of the solution to the problem will be found inside schools; other parts will be found in the halls of the State Legislature, others in the Governor's office; still others will be found within the business community and with parents and PTA's from one end of a State to the other; still others will be found with nonprofit groups working for improvement of schools. Thus, an effective initiative is one which has an "inside" strategy (i.e., within education and public policy circles) and an "outside strategy" (i.e., reaching parents, communities, business leaders).

Within the last year, the North Carolina SSI project undertook a major assessment of how it was structured and how it could contribute to positive changes in North Carolina. In fact, the original motivation for this study was the recognition by the SSI project team that the State needed a road map, a plan which could suggest a way to bring the resources of the state and federal government together.

If the Governor and the Education Cabinet move to elevate mathematics and science to a priority level, there could be a logical marriage of state and federal resources and goals. SSI's resources, channeled into the work of the Education Cabinet, could make possible a major initiative which otherwise would require additional state staffing and allocations. Thus, the effort to establish the Education Cabinet as a force for educational coherence combined with the National Science Foundation's goal of supporting states which attempt to bring about broad-based change, offers North Carolina a rare opportunity to move forward.

This report is issued in the hope that it will bring about a redoubling of the efforts which have begun to make steady, but slow, progress in the area of mathematics and science. It is also offered in the belief that for North

Carolina to thrive in the years ahead and for its people to gain and hold a decent standard of living, the capacity of our young people to apply mathematics and science concepts to problems they will face as adults could well be an economic dividing line in the years ahead.

On behalf of the Glaxo Foundation, the Public School Forum offers this assessment of the state of mathematics and science instruction in North Carolina to policymakers, to educators, to business leaders, to foundation directors and to members of the public who share our concern with student performance in North Carolina. Some may quibble with the recommendations contained in this report; few can quibble with the need to spark urgency about the level of mathematics and science performance in the State. Whether these recommendations are adopted is far less important than whether the State moves swiftly to insure that North Carolina young people are equipped with the mathematics and science skills they will need in the future.

Postscript

Those involved in this study ended with a gnawing suspicion that if one were to undertake a similar study of, for instance, the teaching of reading or vocational education in North Carolina, it is very likely that the same kind of disconnectedness would be found.

Recognizing that mathematics and science are critical ingredients of a young person's education, but certainly not the only ingredients, the Study Group members hope that this study, and action which comes about as a result of it, provide the State a road map that could be followed if the State moved to improve the delivery of instruction in any area of the school program.

Further, just as the Education Cabinet is beginning to show its potential in the area of collaboration and coordination in the technology arena, the Study Group hopes that this work will suggest an approach to collaboration that has the potential to improve the delivery of services in all areas of the school program.

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The Glaxo Foundation supports activities in North Carolina that help meet the educational needs of today's society and future generations. The Foundation focuses on programs that emphasize the understanding and application of science, mathematics and health at all educational and professional levels.

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